

A MICROBIOLOGICAL SURVEY OF FRESH MEAT PROCESSED AT ABATTOIRS IN GAUTENG, SOUTH AFRICA

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Abstract

The abattoir Hygiene Management System (HMS) was regulated in South Africa under the Meat Safety Act 40 of 2000. Presently, there is no national regulated microbiological standard to compare against meat tested at abattoirs as an indicator of good hygiene practices. The aim of the study was to establish a provincial guideline for a microbiological baseline. This may be used to verify the performance of the implemented HMS. Thirty red meat and twenty-two poultry abattoirs were sampled to determine baseline Total Bacterial Counts (TBCs). The results of this study were compared to standards presently used in the United Kingdom (UK). The results compared favourably.

Keywords: Hygiene Management System, abattoir, TBC, hygiene practices

1. INTRODUCTION

Consumer concerns over safe food (Gellynk et al., 2008) have re-defined the roles played by the state and private sector in food safety control (Martinez et al., 2007). Food safety systems have been regulated as part of a preventative and systematic approach to ensure the safe processing of food (Fearne and Martinez, 2005).

The Hazard Analysis Critical Control Point (HACCP) system is regarded as an effective means of preventing and controlling food contamination during handling and processing (Ehiri et al., 1997). It was adopted by the World Health Organisation (WHO) as an international standard to facilitate international trade (CAC, 2003). Internationally, HACCP-based systems have been regulated as a means of control by food operators (Desmarchelier et al., 2007). Microbiological testing of meat has been shown to be an acceptable method of ensuring optimal food safety (Shale et al., 2006; Jericho et al., 1994). While it is not practical to synchronise the release of products with a laboratory report, testing of meat is nonetheless a good method to verify the effectiveness of implemented systems (Jacxsens et al., 2009).

2. BACKGROUND AND PROBLEM STATEMENT

The Department of Agriculture, Forestry and Fisheries (DAFF) regulated the HMS applicable to registered abattoirs.

The HMS is based on the principles of HACCP but contains specific requirements relevant to abattoirs processing. The slaughter and processing of animals for meat in South Africa is controlled by the Meat Safety Act, Act No. 40 of 2000 (SA, 2000) as well as red meat (SA, 2004) and poultry regulations (SA, 2006).

The HMS is a preventative system intended to reduce the risk of contamination and cross contamination of meat during processing at abattoirs, if correctly implemented (Govender and Genis, 2010). To determine if the HMS is working effectively, internal audits are a regulatory requirement. A tool called the Hygiene Assessment System (HAS), which is a scoring system, is a national audit tool for abattoirs. Provincial veterinary services usually conduct abattoir audits using HAS. However, the HAS is subjective in nature. Thus, in order to verify whether the HMS is working effectively, microbiological testing of meat may be done. Govender (2012) suggested microbiological testing could be periodically carried out in order to set abattoir-specific performance targets that may be reviewed over time towards continual improvement within the HMS at abattoirs.

Microbiological testing of meat at abattoirs in South Africa is not compulsory. It is however done at some abattoirs that supply the big retail supermarkets and other markets due to consumer pressure. The DAFF has published a guideline for microbiological testing of meat including limits for parameters tested e.g. TBCs as described in Veterinary Procedural Notice VPN/IS/2010-01 (SA, 2010). This guideline is applicable only to export abattoirs at this stage. However, these limits are not a national regulatory requirement at non-export abattoirs. There is presently limited research on the national status of microbiological quality of fresh meat and how it may compare to the Veterinary Procedural Notice (VPN) guideline. A baseline level of TBCs may provide insight into the setting of practical standards that could be used in future to verify the effectiveness of hygiene management at abattoirs using the HMS.

3. STUDY AIM AND OBJECTIVES

The focus of this study was to determine the microbiological status of poultry and red meat processed at abattoirs in Gauteng Province, South Africa. A baseline level for hygiene quality indicators was calculated and compared with international standards.

The objectives of the study were to: (i) sample and test carcass meat at selected abattoirs in Gauteng; (ii) determine the average baseline TBCs at the abattoirs per species; (iii) compare average TBCs results with international standards; and (iv) make recommendations towards the development of a microbiological standard in order to verify the effectiveness of the HMS at abattoirs.

4. METHODOLOGY

4.1 Sample Size

A total of 198 red meat and 680 poultry carcasses were sampled from 30 red meat and 22 poultry registered abattoirs in the Gauteng province of South Africa in 2009/10.

Some of the red meat abattoirs selected for this study slaughtered more than one species of animals e.g. cattle (bovine) and/or pigs (porcine) and/or sheep (ovine) at the facility. During the study, samples were collected from all species slaughtered at the abattoir. The red meat abattoirs sampled therefore comprised of 17 bovine, 12 porcine and 7 ovine abattoirs.

Between 5 to 10 carcasses were sampled, with an exception of two red meat abattoirs where 2 and 4 carcasses were sampled. This sample size per abattoir was adopted as recommended by the Food Safety Inspection Services Directive 6420.2 (Food Safety Inspection Services Directive, 2004).

At each of the poultry abattoirs, neck skin samples were collected and were pooled from 5 birds. A total of between 5 and 9 composite samples (of 5 birds each) were collected in sterile tubes per abattoir. A total of between 25 and 45 birds were therefore sampled per abattoir, depending on the size of the abattoir (i.e. more samples were taken at high throughput abattoirs).

4.2 Sampling at red meat abattoirs

Samples were collected according to methods outlined in ISO 17604:2003 (ISO, 2003) and VP/15/2010-01 (SA, 2010) standards using commercial Swab Rinse Kits (SRK Foam Spatula, Copan innovation). Samples were collected by trained Veterinary Public Health officials from carcasses in the chillers. Four specific carcass surface areas were sampled namely, the rump (lower back from the outside), the fore-quarter (shoulder outside), the flank (on the side) and the brisket (ribs on the outside). These sites were selected according to recommendations of the International Standards (ISO/IEC 17604:2003) which is also consistent with the South African Veterinary Procedural Notice VP/15/2010-01 (SA, 2010).

Briefly, samples were collected as follows: SRK tubes containing the sterile swab on a spatula in transport media were unscrewed and the swab removed. The tip of the spatula was pressed against the wall of the tube to remove access liquid. A sterile stainless steel sampling template (10cm x 10cm for large ruminants and 5cm x 5cm for small ruminants and pigs) was used during sampling. This was placed on the sampling site and the spatula was wiped over the sampling sites. Steel templates were sterilized between carcasses at 82°C in sterilizers at the abattoir or in 70% ethanol. After swabbing, the spatula was placed back into the tube and tightly closed.

Samples were placed in clean cooler boxes containing in ice packs and transported to the laboratory on the same day (within 4 hours) after collection.

4.3 Sampling at poultry abattoirs

Poultry samples were collected from neck skins from each bird sampled. Birds were sampled at the abattoir at the point after the final rinse. During sampling, a piece of the neck skin (approximately 5 grams) was cut with sterilized scissors and placed into a sterile plastic bottle. The scissors were sterilized after each bird at 82°C in sterilizers at the abattoir or in 70% ethanol, where sterilizers were not conveniently located. The samples from 5 birds were pooled into one sterile bottle and a total of between 5 to 9 bottles (each with a composite sample of 5 neck skins) were collected. Samples were placed in a clean cooler box containing ice packs and transported to the laboratory on the same day (within 4 hours) after collection.

4.4 Laboratory testing of samples

Samples were tested for total viable bacterial counts (TBCs) at an ISO/IEC 17025 accredited laboratory at Onderstepoort Veterinary Institute (OVI), Pretoria, South Africa. Samples were tested using the pour plate technique as follows: Serial dilutions of the sample (e.g. 10^1 , 10^2 , 10^3 , etc.) were prepared using a non-selective medium. A specified quantity of the diluted sample was aseptically pipetted into a sterile petri dish. Molten and cooled plate count agar was added, followed by gently mixing to distribute micro-organisms throughout the agar. The solidified agar was incubated at 37 ± 1 °C for 48 hours in an aerobic atmosphere. Each viable bacterium present in the sample that grew was counted as a colony forming unit (cfu) per gram or cm^2 of sample.

Results were reported as cfu per 100 cm^2 and cfu per 25 cm^2 of carcass surface swabbed for large animals (bovines) and small animals (sheep and pigs), respectively. Poultry results were reported as cfu/g.

4.5 Data analysis

TBCs that were reported by the laboratory per species sampled were entered on an Excel spreadsheet (Microsoft Excel 2010). The data input was quality checked and analysed using descriptive statistics. TBCs were converted to log scale [mean log (\bar{x})] (McEvoy, et al., 2004) and compared with reference standards (Ashtown Food Research Centre, 2008a and 2008b).

5. RESULTS

Table 1 presents mean, median, range and average log values per species. The wide range shows that the data is widely spread within the mean and the median.

Table 1: Summary TBCs for red meat and poultry carcass at Abattoirs in Gauteng Province

Species	No. of Abattoirs	No. of carcasses sampled	Total no. of samples	Total Viable Bacterial Counts				
				Average cfu/cm ²	Median cfu/cm ²	Range (cfu/cm ²)		Average Log
						Minimum	Maximum	
Bovine	17	97	388	352	130	7	1512	2.1
Porcine	12	71	284	3263	902	40	24550	2.9
Ovine	7	30	120	1113.1	463	222	4153	2.8
Poultry	22	680	136 ^a	116508 ^b	44000 ^b	1402 ^b	582500 ^b	4.8

^a Number of pooled composite samples for poultry (5 carcass neck skins) per tube

^b Total viable bacterial counts for poultry are expressed as cfu/g

Table 2: Reference standards for carcass surface TBC (Ashtown Food Research Centre, 2008a and 2008b)

Species	Reference Standards			
	Maximum Acceptable count (cfu/cm ²)	Optimal Log	Acceptable Log	Unacceptable Log
Bovine	100000	≤ 3.5	3.5 - 5.0	>5.0
Porcine	100000	≤ 4	4 - 5.0	>5.0
Sheep	100000	≤ 3.5	3.5 - 5.0	>5.0
Poultry ^a	1,000,000 ^a	<5.1	5.1 - 6.0	>6.0

^a Total Bacterial Counts for Poultry are expressed as cfu/g

The average log values per species were compared to the reference standards in Table 2, and they are within acceptable and optimal levels.

Figure 1 depicts the mean of TBC (cfu/cm²) for bovine carcasses sampled at each of the 17 abattoirs (n=17). The average TBCs of sampled carcasses is presented per abattoir e.g. \bar{x} = 221 cfu/cm² at abattoir 1.

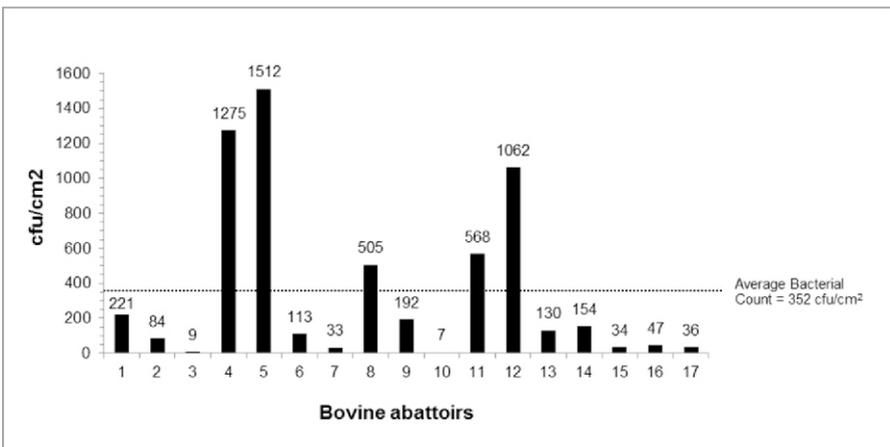


Figure 1: Mean TBCs (cfu/cm²) for bovine carcasses at abattoirs in Gauteng

Further, the overall average was 352 cfu/cm² (Range: 7-1512 cfu/cm²). The overall average, when compared to international standards shown in Table 2, was well within the acceptable limit of 100,000 cfu/cm².

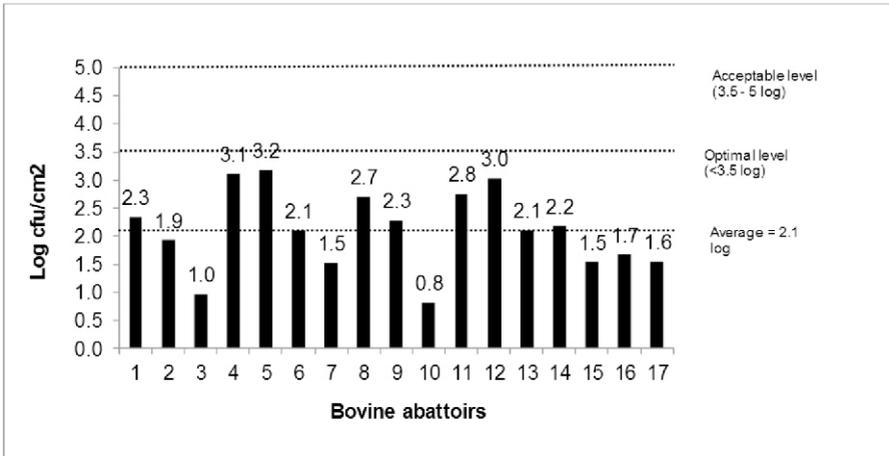


Figure 2: Mean TBCs expressed as a log value for bovine carcasses at abattoirs in Gauteng

The mean log for bovine abattoirs was 2.1 log cfu/cm² (n = 17) (Figure 2). When compared to the reference standard (Table 2), the standard of <3.5 log cfu/cm² reflects a favourable result from sampled abattoirs. This average also compared favourable to a Switzerland study on bovine carcasses which reported 2.1 to 3.1 log cfu/cm² (Zweifel et al., 2005).

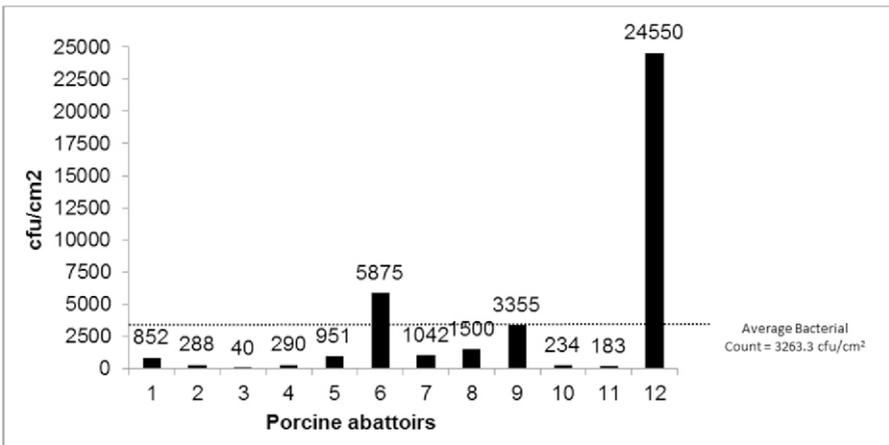


Figure 3: Mean TBCs (cfu/cm²) for porcine carcasses at abattoirs in Gauteng

Figure 3 depicts the mean TBCs (cfu/cm²) for porcine carcasses sampled at each of the 12 abattoirs (n=12). The average TBC of sampled carcasses is presented per abattoir e.g. \bar{x} = 852 cfu/cm² at abattoir 1. Further, the overall average was 3263 cfu/cm² (Range: 40-24550 cfu/cm²). The overall average, when compared to international standards (Table 2), was well within the acceptable limit of 100,000 cfu/cm².

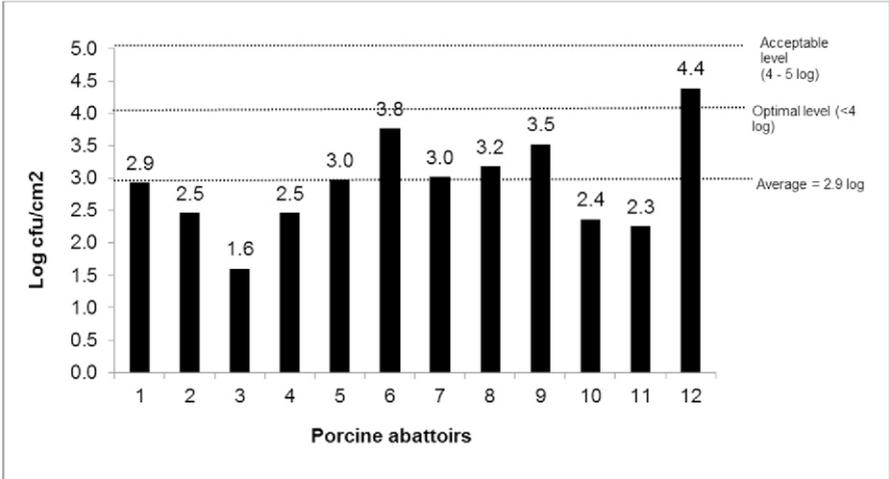


Figure 4: Mean TBCs expressed as a log value for porcine carcasses at abattoirs in Gauteng

The average log was 2.9 log cfu/cm² from 12 abattoirs (n=12) (Figure 4). When compared to the acceptable and optimal reference standard of <4 log cfu/cm² shown in Table 2, the results from sampled abattoirs were well within limits.

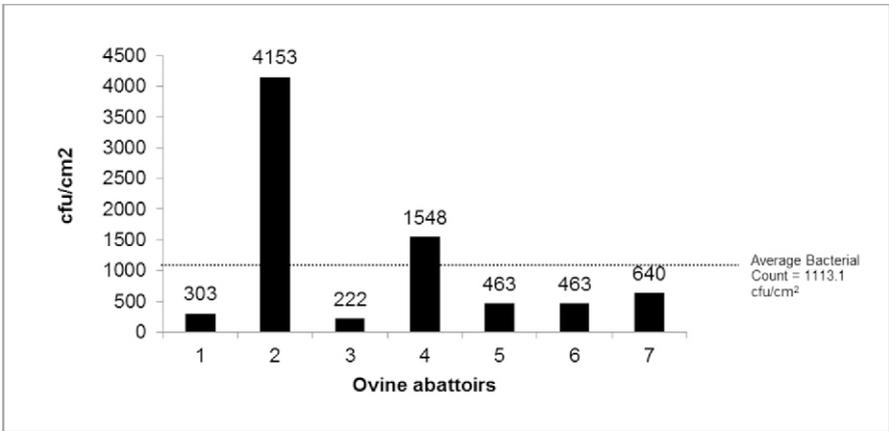


Figure 5: Mean TBCs (cfu/cm²) for ovine carcasses at abattoirs in Gauteng

Figure 5 depicts the mean TBCs (cfu/cm²) for ovine carcasses sampled at each of the 7 abattoirs (n=7). The average TBC of sampled carcasses is presented per abattoir e.g. \bar{x} = 303 cfu/cm² at abattoir 1. Further, the overall average was 1113 cfu/cm² (Range: 222-4153 cfu/cm²). The overall average, when compared to international standards shown in Table 2, was well within the acceptable limit of 100,000 cfu/cm².

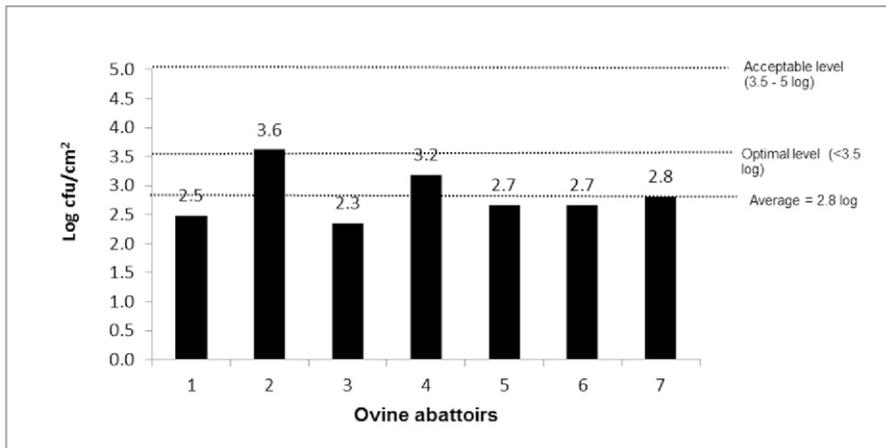


Figure 6: Mean TBCs expressed as a log value for ovine carcasses at abattoirs in Gauteng

The average log was 2.8 log cfu/cm² (n=7) (Figure 6). When compared to the acceptable and optimal reference standard of <3.5 log cfu/cm² as shown in Table 2, this reflected a favourable result from sampled abattoirs.

Figure 7 depicts the mean TBCs cfu/g for poultry carcasses sampled in each of the 22 abattoirs (n=22). The average TBCs of sampled carcasses is presented per abattoir e.g. \bar{x} = 151000 cfu/g at abattoir 1. Further, the overall average was 116508 cfu/g (Range: 1402 - 582500 cfu/g). The overall average, when compared to international standards shown in Table 2, is well within the acceptable limit of 1,000,000 cfu/g.

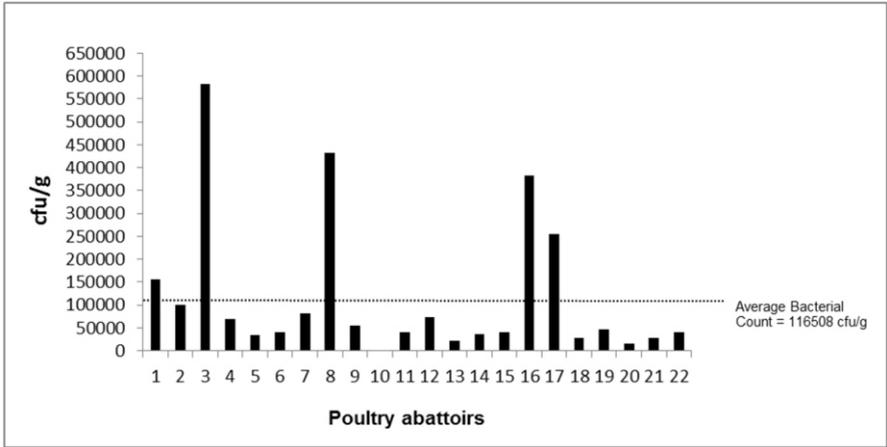


Figure 7: Mean TBCs (cfu/g) for poultry carcasses at abattoirs in Gauteng

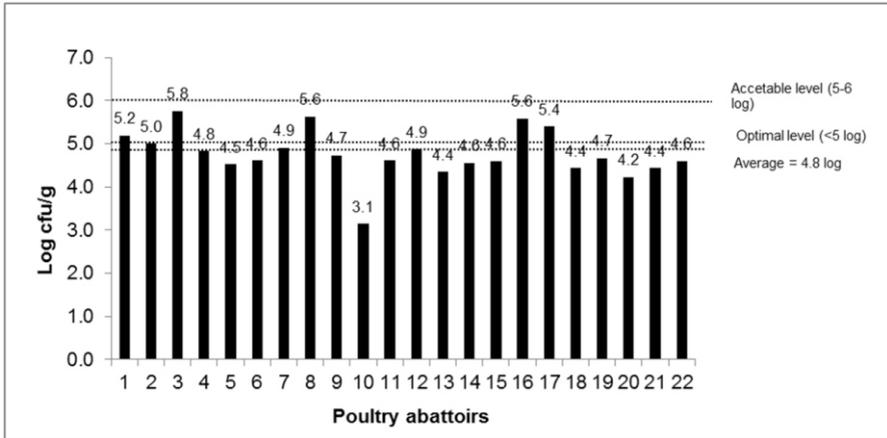


Figure 8: Mean TBCs expressed as a log value for poultry carcasses at abattoirs in Gauteng

The average log was 4.8 log cfu/g (n=22) (Figure 8). When compared to the acceptable and optimal reference standard of <5 log cfu/cm² shown in Table 2, the results from sampled abattoirs were favourable.

6. DISCUSSION AND RECOMMENDATIONS

The results of this study compare favourably to international standards reported elsewhere (Ashtown Food Research Centre, 2008a and 2008b; McEvoy, et al., 2004). The results give a clear indication of an effective system for hygiene processing of meat at abattoirs in Gauteng Province.

They can be used as an objective measure of HMS and a proxy of the effectiveness of HAS tool used to assess HMS at the abattoirs in South Africa. The wide variation of the results between abattoirs as demonstrated by the wide range of average TBCs shows the different levels that abattoirs are at in the implementation of HMS towards processing of safe meat. The results show that while the majority of abattoirs have counts that are below the overall average for each species of animal, some abattoirs have higher counts which although they still fall within the acceptable limits of published international standards, there is room for improvement in hygiene processing of meat.

Extrapolation of the results for use as a microbiological guideline for processing of safe meat at all the abattoirs in the country must however be done with caution for the following reasons: i) abattoirs from only one province were sampled; ii) abattoirs were sampled only once (cross-section study) and therefore may not be truly reflective of the general slaughter practices at the abattoirs; and iii) only TBCs were determined as opposed to screening for specific foodborne pathogens. It is also important to note that although abattoirs may have low TBCs they may still harbour foodborne pathogens that may cause food poisoning. Foodborne pathogens like *E. coli* O157:H7 are known to have very low infectious doses (Cassina *et al.*, 1998) and may therefore be present as contaminants on the carcasses despite the low TBCs.

Despite the above limitations, the study, however, presents the first step towards development of a baseline standard or guideline for microbiological indicators for hygiene processing of meat at abattoirs in South Africa. Such a guideline, may greatly facilitate verification and validation of the regulated HMS at the abattoirs. Central co-ordination, by the national veterinary authority in DAFF, in developing a national guideline is required to ensure inclusion of abattoirs in all the nine provinces of South Africa. Such a study should be correlated with HAS audits in order to validate the results.

The researchers make the following recommendations when approaching the development of such a guideline.

6.1 Future study approaches

Currently, there are no regulated national reference standards for assessing the hygiene processing of fresh meat in South Africa. A longitudinal study approach is recommended, involving all nine provinces in South Africa. A larger sample size may be required to improve reliability and sampling should be repeated at the selected abattoirs over a period of time. Perhaps within a shorter period e.g. 3 years, a national baseline level of bacteriological indicators can be developed from the proposed study and further testing over a longer period maintained in order to assess the consistency of performance of abattoirs in comparison to the baseline. Such an approach may assist in the further development and strengthening of future standards.

6.2 Sampling and testing

It is recommended that the methodology adopted in this study be used in future studies. This is to ensure comparison with international research and standards that are widely acceptable by government and industry. In addition, as was in this study, ISO/IEC 17025 accredited laboratory facilitates should be utilised in order to maintain integrity of the results obtained.

6.3 Data analysis

Working towards the development of meat safety microbiological guidelines may require more advanced statistical methods of analysis to determine the statistical significance of results collected. This may not only stand up to academic critique but may also enhance industry and government acceptability.

6.4 Seasonal influence

The proposed longitudinal study may also consider other variables that may influence microbial levels on meat such as seasonal changes. Some researchers have shown that microbial levels peaked during summer while others showed no significant difference (Barkocy-Gallagher, et al., 2003 and McEvoy et al., 2003).

6.5 Validation of the HMS and HAS

Although this study demonstrated that microbiological indicators compared well with international standards, it does not provide adequate information to draw conclusions on the validation of the HMS and HAS. Such studies should consider correlation with microbiological indicators where statistical significance testing should be central to the study approach. Future studies may also investigate the correlation of microbiological indicators to critical control points of HMS (Hudson, et al., 1996) amongst low and high throughput abattoirs. Such information may provide valuable insight to regulators towards validation of HMS and improving objectivity of HAS.

7. CONCLUSION

The utility of a national regulated standard for microbiological acceptability applicable to fresh meat processed at all abattoirs in South Africa may be useful to verify the effectiveness of the regulated HMS at abattoirs. This may greatly facilitate the farm to fork approach of meat safety control in South Africa (Govender and Katsande, 2011).

This study emphasizes the need to align microbiological sampling and testing methodology to international methods to facilitate comparison and equivalence of assurance provided by the HMS, should verification of the HMS through microbiological testing be regulated. Objective verification may provide local and international consumers with confidence that meat processed at South African abattoirs with fully implemented HMSs is safe.

The authors believe that the recommendations made in this paper may facilitate the development of a more robust national baseline standard for non-export abattoirs in South Africa. It may be more readily accepted by industry and government for application due to its practicality and relevance to the South African context.

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